JPPIPA 9(7) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Analysis of Natural Science Education Innovations Based on The STEAM Approach: A Systematic Literature Review

Shofia Maghfiroh[1*], Insih Wilujeng[1], Suyanta[2], Sabar Nurohman[1], Sri Rejeki Dwi Astuti[2]

[1] Magister of Science Education, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia.
[2] Magister of Chemistry Education, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia.

Received: May 24, 2023
Revised: June 14, 2023
Accepted: July 25, 2023
Published: July 31, 2023

Corresponding Author:
Shofia Maghfiroh
shofiamaghfiroh.2021@student.uny.ac.id

DOI: 10.29303/jppipa.v9i7.3998

Abstract: The purpose of this study was to find out various kinds of science learning innovations and educational developments using the STEAM approach. The method used in this research is a systematic literature review by analyzing 23 Scopus-indexed articles and 7 Sinta-indexed articles. The results of the study show that science learning is developed on the STEAM approach implementing learning applications that are integrated with traditional musical instruments, integration strategies, SSIT-based, traditional sciences, professional development pathways, implementation PjBL Learning model, and Next Generation Science Standards (NGSS). The development of education in the STEAM approach is very rapid, it is evident that the level of success of teachers in STEAM-based learning increases the ability of students both in terms of cognitive, psychomotor, and affective. It can be interpreted that the application of the STEAM approach is very important to improve the success of the quality of education on a small or large scale.

Keywords: Innovations; Natural science education; STEAM approach

Introduction

Education is based on psychological, sociological, epistemological, and pedagogical aspects that underlie the implementation of learning (ElSayary et al., 2022). Education has an important role in preparing the nation's golden generation for the future (Maghfiroh et al., 2023). Learning can be defined as an activity in which there is a process of interaction between students, education, and the surrounding learning environment. Learning activities can train students to use educational principles and learning theories which are the main determinants. The teacher acts as a facilitator when learning activities take place. While in class, there is intensive communication between the teacher and students so that they can carry out learning psychologically and physically in order to achieve educational goals (Sulthon, 2016). Learning will be more meaningful if carried out by involving active students in the classroom. In implementing learning, of course, it is guided by the education system that has been made.

The education system studies different types of concentrations in certain fields. One of the materials taught to students is natural science education. Science is an effort that is systematically arranged to create, build, and organize knowledge about natural phenomena found in the surrounding environment. Science can be said to be a collection of systematic theories. The application of natural science, which is more limited to the phenomena found in nature, then develops through scientific methods (Lestiana et al., 2018). Science is one the subjects consisting of a combination of several sciences, namely, physics, chemistry, and biology (Rosidi, 2015). Events that occur in nature can be either abstract or concrete and require specific knowledge to study further using the scientific method, namely natural science. These symptoms are closely related to everyday life. The application of science learning can be meaningful when the teacher applies several renewable innovations when teaching and learning activities take place.

Science and technological developments have changed the world as the fourth industrial revolution.

How to Cite:
Maghfiroh, S., Wilujeng, I., Suyanta, Nurohman, S., & Astuti, S. R. D. (2023). Analysis of Natural Science Education Innovations Based on The STEAM Approach: A Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 239–245. https://doi.org/10.29303/jppipa.v9i7.3998

One of the important elements for increasing economic growth and national competitiveness in this era is preparing a more innovative learning system and increasing competency graduates who have learning and innovation skills in the 21st century. The implementation of learning shows that students are less actively involved in class (Sunami & Aslam, 2021). Teachers' knowledge of the STEAM approach is still underdeveloped (Nasrah et al., 2021). Based on the problems that have been described, the authors are interested in conducting research with the title "Analysis of Natural Science Education Innovations based on the STEAM Approach: a Systematic Literature Review". The purpose of the article is to find out various kinds of science learning innovations and educational developments using the STEAM approach.

Method

The methodology used in this study was a systematic literature review by analyzing 23 Scopus indexed articles and 7 Sinta indexed articles. This method is a method that focuses on stages including identifying key terms, determining the place of literature, evaluating and selecting literature critically for review, compiling selected literature, writing literature reviews, and making conclusions (Creswell, 2012). The literature review was carried out by discussing and evaluating previous research on science learning innovations based on the STEAM approach. Literature is selected online based on relevant journals. The search was conducted through Scopus indexed open access journals. The limitations of the review are in Table 1.

The data used is secondary data obtained indirectly by using articles in international journals. The systematic literature review steps consist of: (1) Planning, this step is the formulation of the next stage and determining research questions, (2) Review, this stage focuses on searching literature from various articles in the database, then articles are grouped according to type, and (3) Documentation, in this step all the findings from the selected literature are written down and then elaborated. Based on the findings can make the basis for answering research questions. Based on the findings, it can be used as a basis for answering the research questions presented in Table 2.

Table 1. Article Selection Criteria

Publication Year	2015 - 2023
Databases	Scopus indexed articles (Q1, Q2) and sinta indexed articles (Sinta 1 and Sinta 2)
Document type	Article
Subject	Students and teachers
Journal Name	Eurasia Journal of Mathematic, Science, & Technology Education; Smart Learning Environments; International Journal of STEM Education; Asia-Pacific Science Education; Jurnal Pendidikan IPA Indonesia, Jurnal Inovasi Pendidikan IPA; Jurnal Penelitian Pendidikan IPA.
Keywords	STEAM, Science learning

Table 2. Articles Reviewed

Journal	Number of papers	Percentage (%)
Eurasia Journal of Mathematics, Science, & Technology Education	13	43
Smart Learning Environments	2	7
International Journal of STEM Education	6	20
Asia-Pacific Science Education	1	3
Jurnal Pendidikan IPA Indonesia	1	3
Jurnal Inovasi Pendidikan IPA	1	3
Jurnal Penelitian Pendidikan IPA	6	20
Total	30	100

Result and Discussion

Results

The research results in this literature review are in the form of analysis and summaries of data from various articles that have been obtained from international journals indexed Scopus and national journals indexed Sinta. Based on the search, thirty related articles were obtained which are presented in Table 3.

Table 3. STEAM-Based Science Learning Innovations

Researcher and Year	Findings
(Park et al., 2016)	Teachers in South Korea have a positive view of the role of STEAM Education
(Jho et al., 2016)	Active participation of teachers in STEAM Education in Korea
(Kim & Chae, 2016)	Developing STEAM programs in the context of teaching and learning Korean traditional musical instruments
(Chaaban et al., 2021)	A sequential mixed methods approach to investigate learners in a teamwork setting at Qatar University
(Shukshina et al., 2021)	Comparative analytical review of trends and prospects for the development of STEAM Education in the Russian Federation

Researcher and Year	Findings
(Rodríguez-Nieto & Alsina, 2022)	A global approach is articulated to analyze mathematical connections in everyday practices that are integrated with culture
(Jeong & Kim, 2015)	Environmental activity-based project performance has an effective effect on STEAM Education
(Kim, 2016)	The benefits of traditional science as a medium that connects STEAM and the humanities
(Kim & Kim, 2016)	Developing and validating competency teaching evaluation indicators in STEAM Education
(Kim et al., 2019)	Contribution to the preparation of new technological demands implemented in STEAM learning
(ElSayary et al., 2022)	The use of interactive technology in developing preservice STEAM competencies
(Ng et al., 2022)	Conceptualization of STEAM practices in early childhood education
(Shukshina et al., 2021)	Comparative analytical review of trends and prospects for the development of STEAM Education in the Russian Federation
(Alexopoulos et al., 2021)	Effects of long-term STEAM interventions on cognitive processes related to creativity and their relationship to the intrinsic and extrinsic components of science motivation
(Herro et al., 2017)	Co-Measure assessment rubric in STEAM learning
(Kijima et al., 2021)	Increased interest in Engineering, greater creative confidence, more positive perceptions of STEAM, levels of empathy, and pro-social factors more varied views of career choices
(Kang, 2019)	STEAM Education Initiative in South Korea
(Conradty & Bogner, 2020)	Implementation of the professional development path (PD) in STEAM learning
(Wu et al., 2022)	A comprehensive learning cycle and research framework that integrates taxonomies in the STEAM field
(Hughes et al., 2022)	Integrating science and art in an ongoing large-scale effort investigating the advancement of the Next Generation Science Standards (NGSS)
(Marín-Marín et al., 2021)	The development of STEAM topic research in the field of Education
(Chistyakov et al., 2023)	The average learning with the PjBL model has an influence on student learning, especially in science and STEAM education
(Sung et al., 2023)	Empirical and comprehensive evidence regarding the effectiveness of an integrated STEAM program with developmentally appropriate robotic kits for young children
(Ahmad et al., 2021)	Project assignments make students trained in improving creative thinking skills in the STEAM approach
(Badriyah et al., 2020)	The STEAM approach with the PjBL learning model can improve student achievement
(Asrizal et al., 2023)	Learning by applying the STEAM approach dominates middle school students by implementing project assignments
(Sakdiah et al., 2022)	STEAM Learning Against Science Process Skills by applying the PjBL learning model
(Subiki et al., 2023)	STEAM learning by applying the PjBL learning model is able to improve student learning outcomes
(Habibi, 2023)	The STEAM approach is able to improve students' creative thinking skills on each indicator specifically
(Nurwahidah et al., 2022)	The STEAM approach is carried out by implementing cultural heritage-based project assignments in an area
(Nuraini et al., 2023)	The PjBL learning model improves student learning outcomes by applying the STEAM approach

Discussion

Science Learning Innovation on the STEAM Approach

The implementation of STEAM learning in several schools has resulted in specific improvements in 21st century learning, namely communication skills, critical thinking, creativity, and collaborative abilities (Asti & Andriyani, 2022; Mu'minah & Suryaningsih, 2020). Meaningful learning makes students active when learning takes place. The importance of learning innovation is able to make students more active and creative in their thinking processes.

Based on a literature study, the application of STEAM-based science learning consists of learning that is integrated with traditional musical instruments, strategy integration, SSIT-based, traditional sciences, professional development pathways, and Next Generation Science Standards (NGSS). Research by Kim et al. (2016) states that learning using the STEAM approach can be integrated with traditional musical instruments in South Korea. Learners recognize the meaning and importance of STEAM Education as a problem-solving procedure that results in increased STEAM literacy and basic concept development through various opinions. Implementation of learning can use the PjBL learning model to influence students' thinking (Chistyakov et al., 2023). STEAM learning development can also be integrated with developmentally appropriate robotic kits for young children (Sung et al., 2023).

In research Rodríguez-Nieto & Alsina (2022) stated that STEAM learning through an articulated global approach to analyze mathematical connections in daily practice. Based on the integration strategy, three results can be identified, namely intra-disciplinary connections, inter-disciplinary connections, and connections between subjects practiced by cultural groups. This research

shows that STEAM learning can be related to the cultural concept of the local community. Students better understand a material because its application is closely related to the daily lives of students.

STEAM learning innovation in science material can of course be linked to the potential of the environment in the area around students. The result of the project provided by STIT-based teachers is that environmental activities can be effective in STEAM Education at the secondary school level (Jeong & Kim, 2015). Science learning can also utilize traditional sciences as a medium that connects STEAM and Humanities (Kim, 2016). STEAM learning develops into a multidisciplinary system.

The development of the STEAM approach in the science field can also be linked to the arts sector which is implemented into the Professional Development Path (PD) (Conradty & Bogner, 2020). Integrating creativity into education through PD works and can provide more meaningful learning in science material. Integrating the science and art of the STEAM approach in ongoing large-scale endeavors can be indicative of progress toward the next generation science standards (NGSS) (Hughes et al., 2022).

In national journals it was identified that learning science by implementing the STEAM approach was able to improve student learning outcomes. Learning takes place by applying the Project based learning (PjBL) model. The STEAM approach is identical to project assignments on specific IPA materials. The teacher implements the PjBL model and relates it to the daily lives of students. Utilization of the STEAM approach is able to improve creative thinking skills, collaboration, motivation, and student learning outcomes. Collaboration between friends when completing project assignments is able to overcome a problem in a systematic and structured manner according to the material taught by the teacher. The role of the teacher when students carry out group discussions is only as a facilitator if there are misconceptions about the material that has been presented.

Various science learning innovations that have been studied based on the results of the literature review can be used as a guide for teachers to apply and develop the STEAM approach according to the needs of students. The STEAM aspect can make students able to think at a higher level. Students can complete the results of the STEAM project in science learning by developing their own potential to get solutions to overcome a problem.

Development of Education Using the STEAM Approach

STEAM's approach to science is evolving rapidly over time. The application of the STEAM approach received positive views and was successfully applied during learning (Jho et al., 2016; Park et al., 2016). The STEAM approach by adopting a sequential mixed methods approach can investigate teacher agency in learning, resulting in that the STEAM approach is able to increase effectiveness in learning (Chaaban et al., 2021). The study explains that the application of STEAM has been successful for science learning and makes students more active.

The STEAM approach is one of the revolutionary tools to change Education to be of higher quality. A comparative analytical review of the trends and prospects for the development of STEAM Education in the Russian Federation shows that STEAM is able to foster the transformation of ideas about scientific knowledge and build innovative development processes through the formation of skills in the fields of exact sciences, linguistics, engineering, arts, and so on (Shukshina et al., 2021). Based on the results of the development and validation of competency teaching evaluation indicators in STEAM Education it shows that STEAM learning can improve learning effectiveness (Kim & Kim, 2016).

Teachers' perceptions of STEAM implementation can contribute to preparation for new technological demands from a rapidly changing society and curriculum changes (Kim et al., 2019). The STEAM approach helps teachers to adapt to the rapid development of technology. The use of interactive technology can conceptualize the integration of STEAM practices in Education (ElSayary et al., 2022; Ng et al., 2022). A comparative analytic review of trends and prospects for the development of STEAM Education in the Russian Federation can generate computational thinking, digital literacy, creativity, open-mindedness, soft skills, and so on (Shukshina et al., 2021).

STEAM development based on long-term intervention effects can improve cognitive processes related to creativity and their relationship to intrinsic and extrinsic components in science learning motivation (Alexopoulos et al., 2021). The integration of STEAM learning can increase interest, confidence, creativity, and make students think about a more varied view of career choices (Kang, 2019; Kijima et al., 2021). Based on long-term implementation, it shows that critical factors influence students' attitudes and learning intentions about STEAM Education (Wu et al., 2022).

The study of STEAM development does not yet have a strong line of research, although this aspect is focused on the scientific branch of Education (Marín-Marín et al., 2021). Based on the results of the literature review, it is explained that STEAM studies develop over time. This indicates that the application of STEAM learning in the science field is developing rapidly

according to the conditions and needs of students and schools.

Conclusion

Teaching science through the multidisciplinary integration of aspects of science, technology, engineering, art, and mathematics can make learning more meaningful. Learning innovation based on several results of literature review can be used as a guideline for teachers to implement meaningful learning using the STEAM approach. Based on the results it is also known that the development of education in the STEAM aspect is growing rapidly. The results show that applying the STEAM approach can make students more active, and can improve affective, psychomotor, and cognitive abilities.

Acknowledgment
I would like to thank Prof. Dr. Insih Wilujeng, M.Pd; Prof. Dr. Suyanta, M.Si; Dr. Sabar Nurohman, M.Pd; and Sri Rejeki Dwi Astuti, M.Pd for the support and input that has been given to me. So that I can finish writing a scientific article about the analysis of the STEAM approach to natural science material.

Author Contributions
The authors in this research are academic executors and lecturers. All of author has contribution in this research.

Funding
This research received funding from the Education Fund Management Institute (LPDP) scholarship.

Conflicts of Interest
The author declares no conflict of interest in this research.

References

Ahmad, D. N., Astriani, M. M., Alfahnum, M., & Setyowati, L. (2021). Increasing Creative Thinking of Students by Learning Organization with STEAM Education. *Jurnal Pendidikan IPA Indonesia*, *10*(1), 103–110. https://doi.org/10.15294/jpii.v10i1.27146

Alexopoulos, A. N., Paolucci, P., Sotiriou, S. A., Bogner, F. X., Dorigo, T., Fedi, M., Menasce, D., Michelotto, M., Paoletti, S., & Scianitti, F. (2021). The Colours of The Higgs Boson: A Study in Creativity and Science Motivation Among High-School Students in Italy. *Smart Learning Environments*, *8*(23). https://doi.org/10.1186/s40561-021-00169-4

Asrizal, A., Dhanil, M., & Usmeldi, U. (2023). *The Effect of STEAM on Science Learning on Student Learning Achievement: A Meta-Analysis*. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1650–1657. https://doi.org/10.29303/jppipa.v9i4.3108

Asti, P. N. W., & Andriyani, A. (2022). Improving Critical Thinking Ability and Active Learning of Statistics Materials Through Problem Based Learning Model with STEAM Approach. *Formosa Journal of Sustainable Research (FJSR)*, *1*(2), 133–152. Retrieved from https://media.neliti.com/media/publications/555987-peningkatan-kemampuan-berpikir-kritis-da-9341afe9.pdf

Badriyah, N. L., Anekawati, A., & Azizah, L. F. (2020). Application of PjBL with Brain-Based STEAM Approach to Improve Learning Achievement of Students. *Jurnal Inovasi Pendidikan IPA*, *6*(1), 88–100. https://doi.org/10.21831/jipi.v6i1.29884

Chaaban, Y., Du, X., & Qadhi, S. (2021). Student Teachers' Perceptions of Factors Influencing Learner Agency Working in Teams in A STEAM-Based Course. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(7), 1–15. https://doi.org/10.29333/EJMSTE/10978

Chistyakov, A. A., Kunitsyna, M. L., & Yagudina, R. I. (2023). Exploring The Characteristics and Effectiveness of Project-Based Learning for Science and STEAM Education. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(5), em2256. https://doi.org/10.29333/ejmste/13128

Conradty, C., & Bogner, F. X. (2020). STEAM Teaching Professional Development Works: Effects on Students' Creativity and Motivation. *Smart Learning Environments*, *7*(26). https://doi.org/10.1186/s40561-020-00132-9

Creswell, J. W. (2012). *Educational Research Planning, Conducting and Evaluating Quantitative and Qualitative Research* (Fourth Edi). Pearson Education. Retrieved from https://www.ptonline.com/articles/how-to-get-better-mfi-results

ElSayary, A., Zein, R., & Antonio, L. S. (2022). Using Interactive Technology to Develop Preservice Teachers' STEAM Competencies in Early Childhood Education Program. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(2), em2079. https://doi.org/10.29333/EJMSTE/11649

Habibi, M. M. (2023). Effect of the STEAM Method on Children's Creativity. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 315–321. https://doi.org/10.29303/jppipa.v9i1.2378

Herro, D., Quigley, C., Andrews, J., & Delacruz, G. (2017). Co-Measure: Developing An Assessment for Student Collaboration in STEAM Activities. *International Journal of STEM Education*, *4*(26). https://doi.org/10.1186/s40594-017-0094-z

Hughes, B. S., Corrigan, M. W., Grove, D., Andersen, S.

B., & Wong, J. T. (2022). Integrating Arts with STEM and Leading with STEAM to Increase Science Learning with Equity for Emerging Bilingual Learners in The United States. *International Journal of STEM Education*, *9*(58). https://doi.org/10.1186/s40594-022-00375-7

Jeong, S., & Kim, H. (2015). The Effect of A Climate Change Monitoring Program on Students' Knowledge and Perceptions of STEAM Education in Korea. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*(6), 1321–1338. https://doi.org/10.12973/eurasia.2015.1390a

Jho, H., Hong, O., & Song, J. (2016). An Analysis of STEM/STEAM Teacher Education in Korea with A Case Study of Two Schools from A Community of Practice Perspective. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(7), 1843–1862. https://doi.org/10.12973/eurasia.2016.1538a

Kang, N. H. (2019). A Review of The Effect of Integrated STEM or STEAM (Science, Technology, Engineering, Arts, and Mathematics) Education in South Korea. *Asia-Pacific Science Education*, *5*(6). https://doi.org/10.1186/s41029-019-0034-y

Kijima, R., Yang-yoshihara, M., & Maekawa, M. S. (2021). Using Design Thinking to Cultivate The Next Generation of Female STEAM Thinkers. *International Journal of STEM Education*, *8*(14). Retrieved from https://stemeducationjournal.springeropen.com/articles/10.1186/s40594-021-00271-6

Kim, B. H., & Kim, J. (2016). Development and Validation of Evaluation Indicators for Teaching Competency in STEAM Education in Korea. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(7), 1909–1924. https://doi.org/10.12973/eurasia.2016.1537a

Kim, H., & Chae, D. H. (2016). The Development and Application of A STEAM Programbased on Traditional Korean Culture. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(7), 1925–1936. https://doi.org/10.12973/eurasia.2016.1539a

Kim, M. K., Lee, J. Y., Yang, H., Lee, J., Jang, J. N., & Kim, S. J. (2019). Analysis of Elementary School Teachers' Perceptions of Mathematics-Focused STEAM Education in Korea. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(9), 1–13. https://doi.org/10.29333/ejmste/108482

Kim, P. W. (2016). The Wheel Model of STEAM Education Based on Traditional Korean Scientific Contents. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(9), 2353–2371. https://doi.org/10.12973/eurasia.2016.1263a

Lestiana, I., Aed, M., Hadi, W. P., & Rosidi, I. (2018). Pengembangan Lembar Kerja Siswa (LKS) Berbasis Wondering Exploring Explaining (WEE) Science pada Materi Struktur Bumi dan Dinamikanya. *KONSTRUKTIVISME: Jurnal Pendidikan dan Pembelajaran*, *10*(1), 113–129. https://doi.org/10.35457/konstruk.v10i1.459

Maghfiroh, S., Wilujeng, I., Jumadi, J., & Mayitha, D. (2023). Development of Physics E-Module Based on Discovery Learning to Improve Students' Scientific Literacy. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 447–453. https://doi.org/10.29303/jppipa.v9i2.1733

Marín-Marín, J. A., Moreno-Guerrero, A. J., Dúo-Terrón, P., & López-Belmonte, J. (2021). STEAM in Education: A Bibliometric Analysis of Performance and Co-Words in Web of Science. *International Journal of STEM Education*, *8*(41). https://doi.org/10.1186/s40594-021-00296-x

Mu'minah, I. H., & Suryaningsih, Y. (2020). Implementasi STEAM (Science, Technology, Engineering, Arts and Mathematics) dalam Pembelajaran Abad 21. *Jurnal Bio Educatio*, *5*(1), 65–73. Retrieved from https://jurnal.unma.ac.id/index.php/BE/article/view/2105/1793

Nasrah, N., Amir, R. H., & Purwanti, R. Y. (2021). Efektivitas Model Pembelajaran Steam (Science, Technology, Engineering, Art, and Mathematics) Pada Siswa Kelas IV SD. *JKPD (Jurnal Kajian Pendidikan Dasar)*, *6*(1), 1–13. Retrieved from https://36.89.54.123/index.php/jkpd/article/view/4166

Ng, A., Kewalramani, S., & Kidman, G. (2022). Integrating and Navigating STEAM (in STEAM) in Early Childhood Education: An Integrative Review and in STEAM Conceptual Framework. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(7), em2133. https://doi.org/10.29333/ejmste/12174

Nuraini, N., Asri, I. H., & Fajri, N. (2023). Development of Project Based Learning with STEAM Approach Model Integrated Science Literacy in Improving Student Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1632–1640. https://doi.org/10.29303/jppipa.v9i4.2987

Nurwahidah, N., Nurmawanti, I., Novitasari, S., & Kusuma, A. S. H. M. (2022). Development of STEAM-Based Learning Tools Based on the Sasak Heritage Project. *Jurnal Penelitian Pendidikan IPA*, *8*(6), 2900–2908. https://doi.org/10.29303/jppipa.v8i6.2550

Park, H. J., Byun, S. Y., Sim, J., Han, H., & Baek, Y. S. (2016). Teachers' Perceptions and Practices of STEAM Education in South Korea. *Eurasia Journal*

of Mathematics, Science and Technology Education, *12*(7), 1739–1753. https://doi.org/10.12973/eurasia.2016.1531a

Rodríguez-Nieto, C. A., & Alsina, Á. (2022). Networking Between Ethnomathematics, STEAM Education, and the Globalized Approach to Analyze Mathematical Connections in Daily Practices. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(3), 1–22. https://doi.org/10.29333/EJMSTE/11710

Rosidi, I. (2015). Pengembangan Perangkat Pembelajaran IPA Terpadu Tipe Integrated untuk Mengetahui Ketuntasan Belajar IPA Siswa SMP pada Topik Pengelolaan Lingkungan. *Jurnal Pena Sains*, *2*(1), 14-25. Retrieved from https://journal.trunojoyo.ac.id/penasains/article/view/1348/1152

Sakdiah, H., Ginting, F. W., Rejeki, N. S., & Miranda, A. (2022). Pembelajaran STEAM terhadap Keterampilan Proses Sains Ditinjau dari Sikap Ilmiah Mahasiswa pada Mata Kuliah Kajian Fisika Kejuruan. *Jurnal Penelitian Pendidikan IPA*, *8*(5), 2531–2536. https://doi.org/10.29303/jppipa.v8i5.2313

Shukshina, L. V., Gegel, L. A., Erofeeva, M. A., Levina, I. D., Chugaeva, U. Y., & Nikitin, O. D. (2021). STEM and STEAM Education in Russian Education: Conceptual Framework. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(10), 1–14. https://doi.org/10.29333/ejmste/11184

Subiki, S., Elika, E. T. P., & Anggraeni, F. K. A. (2023). Effect of The Project-Based Learning Model with the STEAM Approach on Learning Outcomes of High School Students the Subject of Material Elasticity. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 745–751. https://doi.org/10.29303/jppipa.v9i2.2926

Sulthon, S. (2016). Pembelajaran IPA yang Efektif dan Menyenangkan Bagi Siswa Madrasah Ibtidaiyah (MI). *Elementary: Islamic Teacher Journal*, *4*(1), 38–54. http://dx.doi.org/10.21043/elementary.v4i1.1969

Sunami, M. A., & Aslam, A. (2021). Pengaruh Penggunaan Media Pembelajaran Video Animasi Berbasis Zoom Meeting terhadap Minat dan Hasil Belajar IPA Siswa Sekolah Dasar. *Jurnal Basicedu*, *5*(4), 1940–1945. Retrieved from https://jbasic.org/index.php/basicedu/article/view/1129

Sung, J., Lee, J. Y., & Chun, H. Y. (2023). Short-Term Effects of A Classroom-based STEAM Program Using Robotic Kits on Children in South Korea. *International Journal of STEM Education*, *10*(1), 1–18. https://doi.org/10.1186/s40594-023-00417-8

Wu, C. H., Liu, C. H., & Huang, Y. M. (2022). The Exploration of Continuous Learning Intention in STEAM Education through Attitude, Motivation, and Cognitive Load. *International Journal of STEM Education*, *9*(35). https://doi.org/10.1186/s40594-022-00346-y